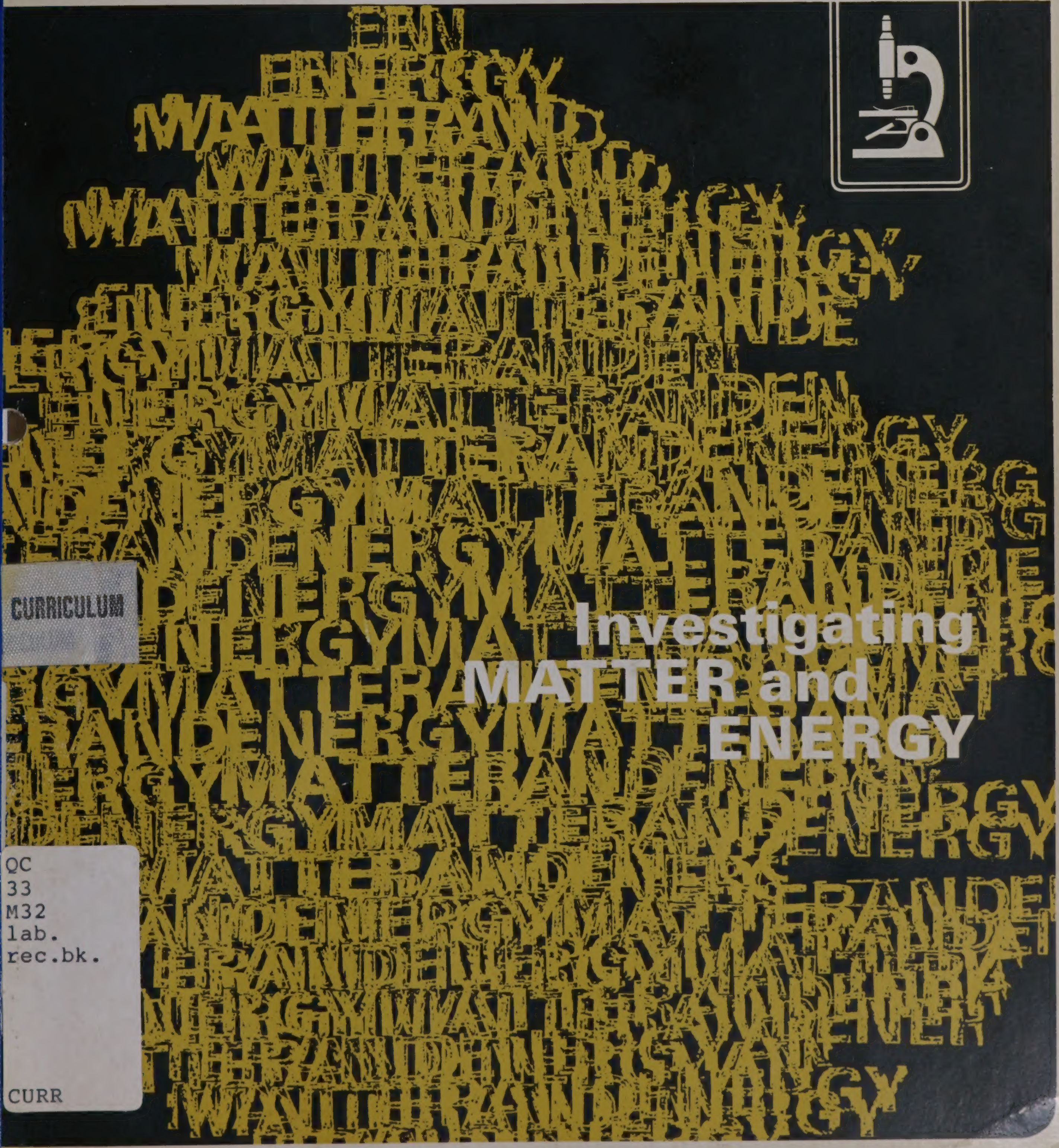
Laboratory Record Book for

PHYSICAL SCIENCE

A LABORATORY APPROACH



Investigating MATTER and ENERGY

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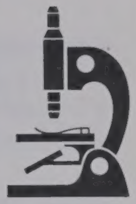

Laboratory Record Book for

PHYSICAL SCIENCE
A LABORATORY APPROACH

Investigating MATTER and ENERGY

John H. Marean · Elaine W. Ledbetter

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Guide to Using the Laboratory Record Book

The professional scientist organizes, records, and interprets all his experimental data. This Laboratory Record Book is designed to guide you in preparing a similar summary of your experiments. Each experiment begins with a problem — a question that arises from a puzzling aspect of our surroundings — and should end with an answer to that question.

We have listed seven elements that are basic steps in scientific experimentation and recording.

1. *Problem:* A problem is stated for each experiment. If the problem is difficult, it might be wise for you to restate it in your own words in the additional space that is provided.

2. *Hypotheses:* A hypothesis is a predicted answer to the problem under investigation. Every investigation in science must involve some guesswork regarding the solution to the problem. Your best guess should be the guide for investigation. We have provided a hypothesis for the problems through Experiment 2–2. Starting with Experiment 2–3 you will be expected to provide your own hypotheses. Always try to state more than one hypothesis even though you may be confident that one of them is a correct prediction.

3, 4. *Attack and Materials:* Local laboratory conditions and class discussion may lead to modification of the suggested attack and material used. Space is available under these entries for brief notes.

5. *Observations:* For experiments involving data collection, a table has been provided. If the data can best be organized by graphing, a grid has been provided. The length of the sides of the squares in the grid is one centimeter. If you need to subdivide them into tenths, it can be done quite easily with a metric ruler. The factor we change (the independent variable) is plotted horizontally, with numbers increasing to the right. The dependent variable, which changes as a result of variation in the horizontal values, is plotted vertically, with numbers increasing upward.

6. *Questions:* The questions will help you to formulate your concluding statements.

7. *Conclusions and Suggestions for Further Investigations:* Your statements must be connected to the problem and the hypotheses. Does the experiment answer the problem? Which hypothesis is verified? The suggestions for further investigation are an important part of experimental work. Most experiments raise new questions for each one that is answered. In addition, your ideas for further investigation provide an avenue of communication with your teacher, providing an exchange of ideas and allowing him to interpret your scientific thinking.

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Reporter ______________________ Date ______________ 1 1 page 4

Team Members ______________________________________

Problem: Is the growth of mold on bread influenced by the amount of moisture present?

Hypotheses: Yes, moisture will encourage the growth of mold on bread.

Attack:

1. Moisten one piece of bread; put it in a jar and seal the jar. Label the jar "moist sample"; include your last name and the date.
2. Put the piece of unmoistened bread in a second jar; seal and label the jar.
3. Place the jars side by side where they will be undisturbed.

Materials:

2 widemouth jars with tight-fitting lids
2 pieces of bread
2 labels

Observations: (Date each entry.)

Questions:

1. What evidence have you observed that supports your hypotheses?

2. How do your results compare with those obtained by other members of the class? Try to explain any differences.

3. What is the purpose of using two jars and two slices of bread? Would it be better to use four jars and four slices of bread?

4. What other factors might influence the growth of mold on bread?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________________

Team Members ____

Problem: How many faces of a marked sugar cube contain a spot?

Hypotheses: It is possible to determine the number of marked faces on a sugar cube by using indirect methods and by comparing experimental results with probable results.

Attack: By shaking a tall container in which the sugar cube is placed, many observations of the faces are possible. Results after shaking each time can be recorded and the whole group of observations studied.

Materials:

sugar cube with an unknown number of spots
tall container, open at one end

Observations: Tally of trials

Trial	Spots	Trial	Spots	Trial	Spots	Trial	Spots
1		26		51		76	
2		27		52		77	
3		28		53		78	
4		29		54		79	
5		30		55		80	
6		31		56		81	
7		32		57		82	
8		33		58		83	
9		34		59		84	
10		35		60		85	
11		36		61		86	
12		37		62		87	
13		38		63		88	
14		39		64		89	
15		40		65		90	
16		41		66		91	
17		42		67		92	
18		43		68		93	
19		44		69		94	
20		45		70		95	
21		46		71		96	
22		47		72		97	
23		48		73		98	
24		49		74		99	
25		50		75		100	
Total spots		Total spots		Total spots		Total spots	

a. Total number of spots observed	
b. Total number of faces observed	
c. Calculated spots per face (a ÷ b)	
d. Calculated spots per cube (c × 6)	
e. Probable spots per cube	

Questions:

1. Analyze the results from the first, second, third, and fourth sets of 25 trials. How do they compare with the results from 100 trials?

Trials	1–25	26–50	51–75	76–100
a. Spots observed				
b. Spots/face (a ÷ 25)				
c. Spots/cube (b × 6)				

2. If a sugar cube has a spot on only one face, in how many trials out of 100 would you expect one spotted face to show? If it has a spot on three faces? If it has a spot on four faces?

3. Combine your 100 trials with the results obtained by four other classmates who seemed to have a similar cube, so that you have 500 trials. What does this do to the value for spots per face and spots per cube?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________

Team Members ____

Problem: What can be learned about spots on the faces of a collection of sugar cubes that cannot be examined separately?

Hypotheses: It is possible to obtain an average for the number of marked and unmarked faces of the collection of cubes.

Attack: Same as Experiment 1–2: shake the sugar cubes in a tall container several times, making observations of the visible faces each time. Study the resulting data as a source of conclusions.

Materials:

collection of 4, 5, or 6 sugar cubes having faces with an unknown number of spots
tall container, open at one end

Observations: Tally of trials

Trial	Number of spots	Trial	Number of spots	Trial	Number of spots	Trial	Number of spots
1		26		51		76	
2		27		52		77	
3		28		53		78	
4		29		54		79	
5		30		55		80	
6		31		56		81	
7		32		57		82	
8		33		58		83	
9		34		59		84	
10		35		60		85	
11		36		61		86	
12		37		62		87	
13		38		63		88	
14		39		64		89	
15		40		65		90	
16		41		66		91	
17		42		67		92	
18		43		68		93	
19		44		69		94	
20		45		70		95	
21		46		71		96	
22		47		72		97	
23		48		73		98	
24		49		74		99	
25		50		75		100	
Total		Total		Total		Total	

Six spotted faces observed ______ times
Five spotted faces observed ______ times
Four spotted faces observed ______ times
Three spotted faces observed ______ times
Two spotted faces observed ______ times
One spotted face observed ______ times
No spotted faces observed ______ times
a. Total number of spots observed = ______
b. Total number of faces observed = ______
c. Fraction of faces with spots (a ÷ b) = ______

Questions:

1. What is the average number of spots per cube in your set of cubes? [(a ÷ b) × 6]

2. If your set of cubes had markings as follows, what would you predict, or hypothesize, as an average value for marked faces?

Cube 1 has two marked faces
Cube 2 has one marked face
Cube 3 has four marked faces
Cube 4 has five marked faces
Cube 5 has six marked faces
Cube 6 has no marked faces

3. What are some of the possible marking combinations that could produce the average you have obtained in this experiment?

4. If you knew the actual markings on all but one of your cubes, could you use this information to determine the markings on this one cube? Explain.

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 1 4 page 13

Team Members ____________________________________

Problem: How can items such as buttons be organized?

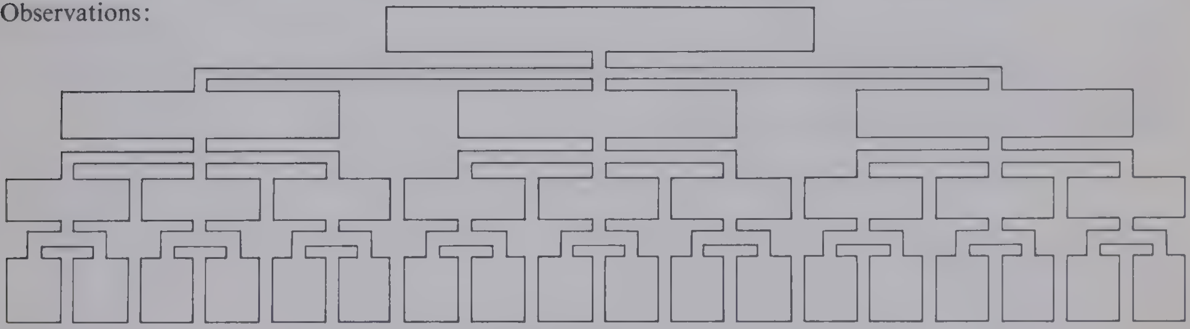
Hypotheses: Many objects, such as buttons, can be grouped according to their characteristics.

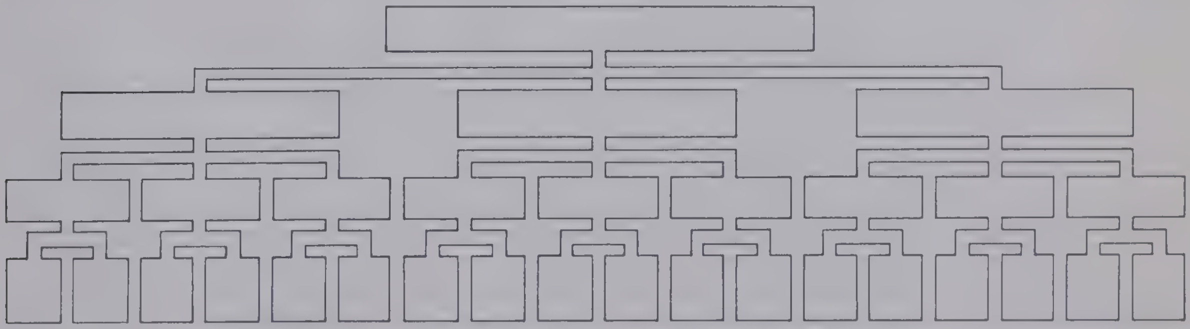
Attack: Study the buttons to establish a basis for categorizing them. Similarities in color, size, shape, and number of holes can be used as bases for categorizing.

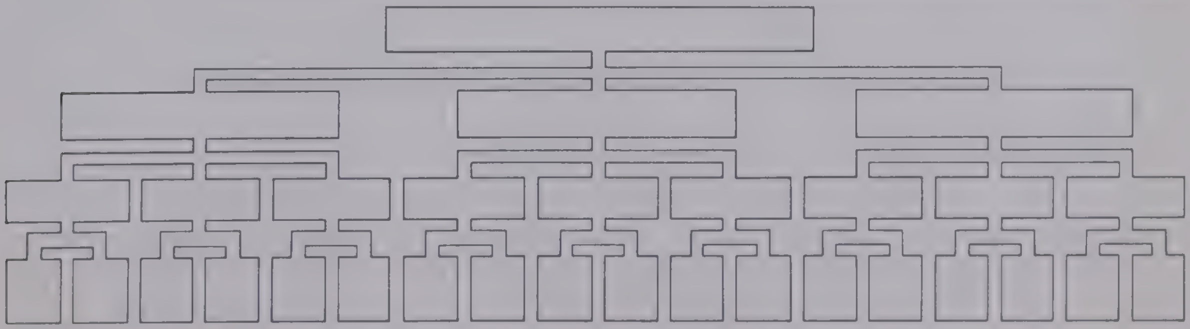
Materials:

buttons, beads, washers, nuts, bolts, or other similar objects

Observations:







Questions:

1. How many classification systems have you devised for your collection?

2. What are some qualities that a good classification system should possess?

3. What classification systems are used as part of the organization of your school?

4. Natural objects, both living and nonliving, represent a great variety. What are some of the classification systems for these objects?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 1 5 page 18

Team Members ______________________________________

Problem: How can measurements be used as a basis for classification?

Hypotheses: Measurements of objects can be used as a basis for grouping objects.

Attack: Measure the diameter or length of each object in a collection. Use the collection of measurements to identify categories based on size.

Determine the mass of each object and compare these values with the diameters as an alternative basis for categorizing.

Fit these size and mass measurements into a classification system that also uses other characteristics of the objects.

Materials:

collection of buttons or similar objects
metric ruler
balance

Observations:

Button	Diameter (mm)	Mass (g)	Button	Diameter (mm)	Mass (g)
1			21		
2			22		
3			23		
4			24		
5			25		
6			26		
7			27		
8			28		
9			29		
10			30		
11			31		
12			32		
13			33		
14			34		
15			35		
16			36		
17			37		
18			38		
19			35		
20			40		

Questions:

1. What are some advantages of a classification system based on measurements?

2. Is it possible to use measurements as a form of classification without using categories? Explain your thinking.

3. Draw a histogram on the grid at the right. Plot the frequency (number of buttons) vertically for each size range listed along the horizontal axis.

4. What size button appears most frequently?

5. What is the median size?

Conclusions and suggestions for further investigation:

Reporter ______________________ Date ______________ 2 1 page 32

Team Members ____

Problem: What evidence for its structure can be obtained by watching water as it freezes, boils, and condenses?

Hypotheses: Close observation of freezing, boiling, and condensing can provide insight into the structure of water.

Attack: Boil a small amount of water in a test tube. Condense and freeze moisture on the surface of a can. Examine the moisture and the frost with a magnifier and, if possible, under the microscope.

Materials:

- test tube
- water
- magnifier
- glass slide
- test tube holder
- source of heat
- small metal can
- table salt
- crushed ice
- microscope (optional)

Observations:

Questions:

1. Does water seem to leave the test tube in a continuous stream as it boils away, or does it seem to leave in particle form?

2. Does the water look continuous or particulate as it condenses on the cold can?

3. What evidence have you observed for continuous or particulate qualities in the frost on the can?

4. Can you build a mental picture of continuous matter going through the processes you have observed? Of particles going through the processes?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 2 2 page 33

Team Members ______________________________________

Problem: What evidence for sulfur's structure can be obtained by observing sulfur before it melts, as it melts, and as it cools?

Hypotheses:

Attack: Examine sulfur with a magnifier and, if possible, with a microscope. Melt the sulfur by heating it and solidify it by cooling in the air and then pouring into some water. Then dissolve some of it in carbon disulfide.

Materials:

- piece of roll sulfur
- small test tube
- test tube holder
- source of heat
- glass slide
- filter paper
- funnel
- stirring rod
- magnifier
- beaker
- cold water
- carbon disulfide
- microscope (optional)

Observations:

Questions:

1. Did you detect any evidence that some of the sulfur had vaporized?

2. Suggest reasons why sulfur changes its color and its liquid character as you continue to heat it. Try to use both a particle theory and a continuous theory for your reasons.

3. How are sulfur crystals similar to and different from water crystals?

4. How does the amorphous sulfur change a few days after its manufacture?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 2 3 page 37

Team Members ______________________________________

Problem: Can a large marble model be built that would have the regular appearance exhibited by crystals?

Hypotheses:

Attack: Use marbles to build models that show the same regular angles and sides exhibited by crystals.

Materials:

- 50 to 75 marbles or other spheres
- quick drying cement
- candle
- several strips of cardboard

Observations:

Questions:

1. Do your models show evidence of faces with fixed angles between them similar to those observed in crystals?

2. What would happen if some of the marbles were of a different size?

3. Do the particles for models necessarily have to be spheres? Could models be made with sugar cubes?

4. Do your models support the particle theory or the continuous theory?

Conclusions and suggestions for further investigations:

Reporter ____________________ Date ____________________

2
4
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Team Members ____________________

Problem: Do the forms of sulfur differ in density?

Hypotheses:

Attack: Determine the density of the various forms of sulfur by obtaining volume and mass for each form and then compare the values.

Materials:

roll sulfur
amorphous sulfur
100-ml graduated cylinder
balance

Observations:

Kind of data	Trials with roll or crystalline sulfur						Trials with amorphous sulfur				
	1	2	3	4	5	6	1	2	3	4	5
a. Mass (by weighing)											
b. Initial volume of water											
c. Volume of water plus sulfur											
d. Volume of sulfur (c − b)											
e. Density of sulfur (a ÷ d)											

Questions:

1. Do your results indicate a density difference in the forms of sulfur?

2. Do your results indicate that the density of each kind of sulfur is constant?

3. What kinds of errors might have caused your trials on the same sample to vary?

4. If this experiment produced evidence that the samples were the same in density, would you accept this as a valid result? Explain.

5. How do the results of this experiment fit into the two theories of matter?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________

Team Members ______________________________________

Problem: What is the relation of the mass of a floating object to the mass of the liquid it displaces?

Hypotheses:

Attack: Compare the mass of the floating object with the mass of the liquid that was displaced as the object sank into the liquid.

Materials:

wooden sample, 5 to 10 cm long cut from 2-cm doweling
100-ml graduated cylinder
balance
water
gasoline, kerosene, or alcohol

Observations:

Observations:	Samples			
Kind of data	1	2	3	4
a. Initial volume of water				
b. Final volume (water plus sample)				
c. Volume of submerged portion of sample (b − a)				
d. Initial mass of water plus graduated cylinder				
e. Final mass of water, container, and sample				
f. Mass of sample (e − d)				
g. Density of water (f ÷ c)				
h. Mass of container filled with water to level recorded in (b)				
i. Mass of water displaced (h − d)				
j. Density of water added (i ÷ c)				
l. Initial volume of gasoline				
m. Final volume gasoline + sample				
n. Volume of submerged portion of sample (m − l)				
o. Initial mass of gasoline + container				
p. Final mass of gasoline, container, and sample				
q. Mass of sample (f)				
r. Density of gasoline (q ÷ n)				
s. Specific gravity of gasoline $\frac{r}{g}$ or $\frac{r}{j}$ or $\frac{c}{n}$				

Questions:

1. What can you say about the density of an object that sinks in water?

2. What does this experiment imply about the density of ice as compared to the density of water?

3. Density is a constant property for each substance that we know. Offer some possible explanations for this statement, using a theory for the structure of matter.

4. Why does the wooden cylinder displace more gasoline than water?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 2-6 2-7

Team Members ______________________________________

Problem: To build a hydrometer. A hydrometer is better suited to measuring the specific gravity of liquids than a wooden cylinder.

Hypotheses:

Attack: For Experiment 2–6 the transparent plastic drinking straw serves as the floating object. Seal one end with a small bolt that will concentrate the mass at one end. Then insert a narrow, numbered piece of paper into the straw as a scale.

For Experiment 2–7 float the hydrometer in water and then in gasoline. Use the table below to record depths and specific gravities.

Materials:

- transparent plastic drinking straw
- household cement
- lined paper
- bolt
- scissors
- tall cylinder
- gasoline
- tall container

Observations for Experiment 2–7:

a. Total length of hydrometer ________ divisions
b. Depth reading in water ________ divisions
c. Depth reading in gasoline ________ divisions

Specific gravity of gasoline $\frac{b}{c} =$

Scale reading	Depth reading in water divided by each scale reading	= Specific gravity

Questions:

1. Why is your hydrometer a better instrument for measuring specific gravity of liquids than the wooden cylinder?

2. By reading your graph determine the specific gravity of your hydrometer.

3. Why is your study of density important to the overall study of the structure of matter?

4. Explain how density could be useful as a basis for classifying matter.

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 2 8 page 48

Team Members ______________________________________

Problem: Can the density of a liquid mixture be adjusted to make it possible to detect very small density differences in samples of solids?

Hypotheses:

Attack: Tetrabromoethane has a density of 2.96 g/ml. It mixes readily with butyl carbitol (density 0.95 g/ml). Float the sulfur samples on a small quantity of tetrabromoethane. Then add butyl carbitol, drop by drop, until the sulfur sinks. Use your hydrometer to determine the specific gravity value of the mixture.

Materials:

- tetrabromoethane
- butyl carbitol
- samples of roll sulfur, rhombic sulfur, monoclinic sulfur, and fresh and old samples of amorphous sulfur
- test tube
- hydrometer
- dropper

Observations:

Questions:

1. What does this experiment show about the densities of the various kinds of sulfur?

2. Does this method provide a more precise way of detecting density differences than Experiment 2–4? Explain.

3. How can the precision of experiments affect the opportunity to draw conclusions?

4. Devise explanations for the difference in density of the same substance by using the two theories for matter.

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________

Team Members ______________________________________

3
1

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Problem: What are the characteristics of solutions?

Hypotheses:

Attack: Select a number of common laboratory substances and attempt to dissolve them in water. Examine a drop of each solution under a microscope and then evaporate the drop. Filter each solution and examine the filter paper for a residue. Taste the salt and sugar solutions.

CAUTION: Do not taste the copper sulfate—it is poisonous.

Materials:

- sugar cubes
- rock salt crystals
- copper sulfate crystals
- filter paper
- funnel
- glass slides
- stirring rod
- 150 ml beaker
- 6 20-by-150-mm test tubes
- test tube rack
- microscope
- heat source
- water

Observations:

	Sugar	Salt	Copper sulfate
Taste			■
Color			
Appearance of particles			
Is the solid recovered by heating?			
Is the solute removed by filtering?			

(Include sketches of crystal form as part of your record of observations.)

Questions:

1. What properties of solutions can you identify as a result of this experiment?

2. Can you see any reason why the same mass of crystals would dissolve more rapidly when crushed than as large pieces?

3. If matter is made of particles, what does this experiment suggest about the size of the particles?

4. If given two test tubes, one containing water and one containing sugar solution, how could you identify the sugar solution?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________________ 3 2 page 55

Team Members ____

Problem: Are solutions the only form of association produced when substances are mixed?

Hypotheses:

Attack: Study a broader, more diverse sampling of substances than you did in Experiment 3–1. Filter each mixture of substance and water. Let the mixtures stand to see if the materials stay suspended or whether they settle out; shine a beam of light through each mixture. Classify them according to results.

Materials:

- 4 20-by-150-mm test tubes
- table salt
- liquid laundry starch
- finely crushed soil
- graduated cylinder
- stirring rod
- labels
- spoon
- funnel
- filter paper
- test tube rack
- light-beam source
- sugar cubes
- water

Observations:

	Sugar in water	Salt in water	Starch in water	Soil in water
Is the solid removed by filtering?				
Does the solid settle out?				
Does the mixture transmit light?				
Does the beam show in the mixtures?				
Probable classification				

Questions:

1. What seems to be the fundamental difference between solutions, dispersions, and suspensions?

2. Try to explain why light is affected as it is by the various mixtures.

3. List some natural examples of solutions, dispersions, and suspensions.

4. Use the particle theory and the continuous theory to explain the conditions represented by solutions, suspensions, and dispersions.

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________________ 3 3 page 58

Team Members ____

Problem: Does the specific gravity of a solution change with the amount of dissolved solute?

Hypotheses:

Attack: Use the hydrometer made in Experiment 2–6 and the graph made in Experiment 2–7 to determine the specific gravities for a series of sugar solution concentrations. Start with one cube dissolved and read the specific gravity, then add a second cube and read the specific gravity, etc.

Materials:

- 100-ml graduated cylinder (or tall test tube)
- stirring rod
- drinking-straw hydrometer
- several sugar cubes
- specific gravity graph from Experiment 2–7
- water
- balance (optional)

Observations:

Number of cubes dissolved	1	2	3	4	5	6	7	8	9	10
Hydrometer reading										
Specific gravity of solution										
Mass of sugar										
Mass of solution										
Mass of solvent										

Volume of water used __________ ml

Mass of water used __________ g

Questions:

1. The density of sugar is 1.59 g/ml. What do you find to be the average density of sugar cubes? Explain any difference between your answer and the value above.

2. If 1.59 g of sugar are put into 10.0 ml of water, will the volume increase to 11.0 ml? Explain.

3. What increase in volume does each sugar cube produce in your solution?

4. Which theory for matter provides the best explanation for the observations made in this experiment?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 3 4 page 60

Team Members ______________________________________

Problem: What happens to a hypo solution as it cools?

Hypotheses:

Attack: Dissolve a relatively large amount of hypo in water by heating very gently. Once all the hypo is dissolved, allow the solution to cool without disturbing it. When it is at room temperature drop a crystal of hypo into it. Observe the solution closely for appearance of crystals and any temperature change.

Materials:

- distilled water
- 15 g of hypo
- 20-by-150-mm test tube
- test tube rack
- stirring rod
- 100-ml graduated cylinder
- 250-ml beaker
- test tube holder
- heat source

Observations:

Questions:

1. Does this experiment result in what might logically be expected?

2. Suggest reasons why the hypo crystallized.

3. How can you explain the great increase in solubility of hypo as the temperature went up?

4. What does this experiment contribute to your efforts in judging the validity of the two theories for matter?

Conclusions and suggestions for further investigations:

Reporter ____________________ Date ____________________

Team Members ____________________

3
5

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Problem: Does exchange occur between the solution and the crystal form in a saturated solution?

Hypotheses:

Attack: Prepare a saturated solution of potassium aluminum sulfate (alum). Seal it in a beaker with undissolved crystals in the bottom. Set the beaker someplace where the temperature is constant. Observe the beaker every day for several days. Note any change in the crystal surface.

Materials:

- 10 g of potassium aluminum sulfate (alum)
- 250-ml beaker
- stirring rod
- graduated cylinder
- rubber band
- 8-cm square of plastic wrap

Observations:

Questions:

1. Why must temperature be controlled for this experiment?

2. Why should the container be covered?

3. Is this a controlled experiment? Explain.

4. Did you observe evidence of change in the crystal surface?

5. Relate the idea of equilibrium to the two theories of matter. Which theory gives the best basis for explaining equilibrium?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 3 6 page 65

Team Members ______________________________________

Problem: What effect does temperature have on the solubility of substances?

Hypotheses:

Attack: Start with water near 0°C. Add a measured amount of solute and see if it will dissolve at that temperature. If it does add another measured amount. If it does not dissolve, carefully and slowly warm the solution to a temperature at which it does dissolve; then record the temperature and add a second or third measured sample.

Materials:

17 labels
17 small bottles or vials with caps
3 250-ml beakers
heat source
20-by-150-mm test tube
10-ml graduated cylinder
test tube holder
ringstand, ring, and asbestos pad
test tube rack
thermometer
one-hole stopper
ice
chemicals (see text)

Observations:

	Substances	Potassium Nitrate	Ammonium Chloride	Potassium Chlorate	Sodium Sulfate
	Volume of water used				
	Mass of samples				
First Sample	Dissolving Temperature				
	Volume after dissolving				
Second Sample	Dissolving Temperature				
	Volume after dissolving				
Third Sample	Dissolving Temperature				
	Volume after dissolving				
Fourth Sample	Dissolving Temperature				
	Volume after dissolving				
Fifth Sample	Dissolving Temperature				
	Volume after dissolving				
Final Volume					
Final Mass (Water + solute)					

Questions:

1. What effect does temperature have on the solubility of the substances investigated?

2. What effect would evaporation of some of the water have on your results? How can you use your data to check on whether significant evaporation occurred?

3. What happens to the density of the solutions as the amount of dissolved solute and the temperature both rise?

4. Use the two theories for matter in an attempt to interpret what you have observed in this experiment.

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________

3
7
page 67

Team Members ______________________________________

Problem: Do some solids cool their surroundings as they dissolve?

Hypotheses:

Attack: Dissolve a number of substances in room temperature water and note what happens to its temperature.

Materials:

- 20-by-150-mm test tubes
- teaspoon
- crystal model built with marbles and wax
- 250-ml beaker
- mortar and pestle
- ringstand, ring, and asbestos pad
- source of heat
- substances to test
- test tube rack
- 10-ml graduated cylinder
- test tube holder
- water

Observations:

Substances	Ammonium chloride	Potassium nitrate	Sodium sulfate	Copper sulfate
Initial volume of water				
Initial temperature of water				
Final temperature of solution				

Description of copper sulfate before and after heating:

Description of marble model during heating:

Questions:

1. If heat was taken in as the solute dissolved would you expect the heat to reappear as the substance crystallized from solution?

2. Relate what you have observed in this experiment to what you observed in Experiment 3–4 with hypo.

3. Is there any relationship between what you observed in this experiment and what you observed in Experiment 3–6?

4. Attempt to relate the observations of this experiment to the two theories for matter.

Conclusions and suggestions for further investigations:

Reporter ____________________ Date ____________ 3 8 page 70

Team Members ______________________________

Problem: Is the volume of a solution always equal to the sum of the volume of its ingredients?

Hypotheses:

Attack: Very carefully measure and mix a variety of proportions of alcohol and water and compare the sum of separate volumes with the measured volume of the mixture. If the mixture volume becomes too large, remove half and continue to add water to reduce the percentage of alcohol.

Materials:

100-ml graduated cylinder
2 smaller graduated cylinders readable to 0.1 ml
ethyl alcohol
water
thermometer (optional)

Observations:

Volume of alcohol added	Total volume of alcohol	Volume of water added	Total volume of water	Sum of separate volumes	Percentage of alcohol by original volume	Volume together
27 ml	27 ml	3 ml	3 ml	30 ml	90%	
5	32	5	8	40	80	
10	42	10	18	60	70	
0	42	10	28	70	60	
0	42	14	42	84	50	

Discard one-half of the mixture and use the table below to continue changing percentages.

0	21	42	63	84	25	
0	21	21	84	105	20	

Discard one-half of the mixture and use the table below to continue changing percentages.

0	10.5	52.5	94.5	105	10	

Questions:

1. Which of the possibilities that could be identified as hypotheses actually happened?

2. This experiment is with a liquid-in-liquid solution. Would the results be the same for a solid in a liquid?

3. Which theory offers a better explanation for your observations? Why?

4. If particles of solute and solvent were about the same size, what would you predict for the volume of the mixture? If the particles varied greatly in size, what would you predict?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 4 1 page 77

Team Members ______________________________________

Problem: What is the effect of the rate of crystal formation on the size of the crystals formed using sulfur?

Hypotheses:

Attack: Prepare a saturated solution of sulfur in carbon disulfide. Divide the solution into two parts. Allow one solution to evaporate rapidly. The other solution should evaporate as slowly as possible.

CAUTION: Keep carbon disulfide away from heat and open flame.

Materials:

- pieces of roll sulfur
- 20 ml of carbon disulfide
- test tube
- stopper for test tube
- 2 watch glasses
- 150-ml beaker

Observations:

Questions:

1. Are the results of this experiment consistent with the prediction that growing crystals slowly will produce fewer and larger crystals than growing them rapidly?

2. From your knowledge of solubility, explain why temperature needs to be carefully controlled when crystals are grown.

3. Could you use marbles to build a model that has a shape similar to the sulfur crystals?

4. How do the crystals grown in this experiment compare with the forms of sulfur examined in Experiment 2–2?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________________

Team Members ______________________

Problem: What is the effect of the rate of crystal formation on the size of the crystals formed using copper sulfate?

Hypotheses:

Attack: Prepare a hot, saturated solution of copper sulfate in water. Divide into three parts. Cool the three parts at different rates.

CAUTION: Do not boil the solution of copper sulfate.

Materials:

- 20 g of crushed copper sulfate
- source of heat
- test tube holder
- stirring rod
- 20-by-150-mm test tube
- 3 13-by-100-mm test tubes
- 2 beakers
- test tube rack
- hot water
- ice

Observations:

Questions:

1. Are your observations consistent with your predictions?

2. How does the cooling rate affect the size of crystals?

3. Would you say that sulfur particles and copper sulfate particles are the same shape? Explain.

4. Which theory offers the best explanation for the observations in this experiment and in Experiment 4–1? Why?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 4 3 page 79

Team Members ______________________________________

Problem: What conditions must exist for large crystals to form?

Hypotheses:

Attack: Prepare a saturated solution of potassium aluminum alum. Allow a small part of it to evaporate to obtain a seed crystal. Use nylon thread to suspend the seed crystal in the saturated solution. Set the system where the temperature is fairly constant. Observe it at least once a day for about a week.

Materials:

- alum (potassium aluminum sulfate)
- nylon thread
- 20-by-150-mm test tube
- watch glass
- water

Observations:

Questions:

1. Why is it necessary to keep the temperature constant in this experiment? What would happen if it was not kept constant?

2. How can you control the evaporation rate of the solvent?

3. How does the shape of alum crystals compare with the shapes of sulfur and copper sulfate crystals?

4. Is the growth of your crystal consistent with the prediction that slow growth produces large crystals?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 4 4 page 80

Team Members ______________________________________

Problem: Will a substance deposit from solution onto a crystal of another substance?

Hypotheses:

Attack: Select a substance whose crystalline form is similar to that of potassium aluminum sulfate and another that has a different crystalline structure. Suspend an alum crystal in a saturated solution of each. Observe each solution daily for a week or more.

Materials:

2 seed crystals of potassium aluminum sulfate
nylon thread
6 g of potassium chromium sulfate
saturated solution of copper sulfate
2 20-by-150-mm test tubes
2 stoppers for test tubes
test tube rack

Observations:

Questions:

1. Which materials seem to be similar enough to allow growth of one substance on a crystal of the other?

2. If the crystals are made of particles, what does this experiment suggest about particles of various substances?

3. What explanation can you offer for the lack of a clear line between the two substances in the one crystal?

4. Can two solutes exist in the same sample of solvent?

5. What do you predict might happen during crystallization from a solution that contains solutes that do not grow on each other's crystals?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ________________ 4 5 page 81

Team Members ____

Problem: Crystals form as metals are deposited from a solution by chemical reaction. Do these crystals provide evidence of the structure of matter?

Hypotheses:

Attack: Bring pieces of metal in contact with a solution of a compound that contains another metal. As reaction occurs and the second metal appears, examine the deposit very carefully for evidence of crystal formation. Use a magnifier and a microscope as well as the unaided eye.

Materials:

5 g of crushed copper sulfate
silver nitrate solution
iron nail
mossy zinc
magnesium ribbon
copper wire
distilled water
4 13-by-100-mm test tubes
150-ml beaker
test tube rack
magnifier
microscope
8 glass slides

Observations:

	Deposit on iron nail	Deposit on magnesium	Deposit on mossy zinc	Deposit on copper wire	Residue after evaporation
Unaided eye					
Magnifier					
Microscope					

Questions:

1. In which instances does copper seem to be the deposited substance?

2. What evidence is there for crystalline form in the deposits?

3. Is this experiment a source of evidence for one of the two theories for matter?

4. From your general knowledge of metals, do they seem to have some continuous properties?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 4 6 page 83

Team Members ______________________________________

Problem: Will examination of the crystals formed by precipitation provide evidence for the structure of matter?

Hypotheses:

Attack: Observe the formation of the crystals under a microscope by carefully pushing drops of two solutions together.

Materials:

3 clean glass slides
clean stirring rod
microscope
saturated solutions of barium chloride, calcium chloride, magnesium sulfate, and strontium chloride

Observations:

Questions:

1. Why is it important to have clean glass slides and a clean stirring rod for use in this experiment?

2. Do the visible crystals change in appearance when the water has evaporated?

3. Examine the dry deposits carefully. Is there any evidence for a second or third crystal form? Is there a reason why more than one kind of crystal might be present?

4. Do the observations of this experiment provide further evidence favoring one of the two theories for the structure of matter?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________________

Team Members ______________________________________

4
7

page 84

Problem: What additional information on crystal formation can be obtained by observing the freezing of a melted substance?

Hypotheses:

Attack: Warm a very small amount of salol on a glass slide until it melts. Then observe it under a microscope or magnifier as it cools and crystallizes.

Materials:

- glass slide
- microscope or magnifier
- spoon or spatula
- salol (phenyl salicylate)
- benzoic acid

Observations:

Questions:

1. How does the cooling rate seem to affect the rate of crystallizing?

2. Do you observe any evidence that supercooling takes place in the drop?

3. When the substance has solidified does it have a clearly crystalline appearance?

4. Does this experiment cause you to modify your views about which theory for matter is the better one?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________

Team Members ______________________________________

5

1

page 95

Problem: What is the distinction between temperature and heat?

Hypotheses:

Attack: Use a burner with fairly intense and constant heat to heat a large iron nail and 200 ml of water in a beaker. Heat the water and the nail for the same length of time. Test the temperature of the nail by touching it to a piece of paper. Test the temperature of the water with your finger.

Materials:

250-ml beaker
200 ml of water
iron nail
forceps or pliers
source of heat
ringstand, ring, and asbestos pad
paper

Observations:

Questions:

1. Did both substances absorb heat from the burner?

2. How did the manner of absorption differ?

3. Distinguish between intensity of heat and quantity of heat.

Conclusions and suggestions for further investigations:

5
2

page 96

Reporter ______________________ Date ______________

Team Members ____________________________________

Problem: Is the human nervous system when used directly a reliable source for sensing heat and temperature?

Hypotheses:

Attack: Expose your senses to different heat and temperature conditions. Use three containers of water—one quite cold, one at room temperature, and one quite warm. Put your hands into all three at separate intervals.

Materials:

3 widemouth containers with 1000-ml capacity
quantities of cold, hot, and room temperature water

Observations:

Questions:

1. Are the nerves in your hands reliable temperature sensors? Explain.

2. What other parts of the body might be better temperature sensors than your hands?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 5 3 page 99

Team Members ______________________________________

Problem: What response to heat does matter make that might provide a basis for measuring temperature?

Hypotheses:

Attack: Prepare a system that allows the expansion of a heated sample of water to occur only along a narrow tube.

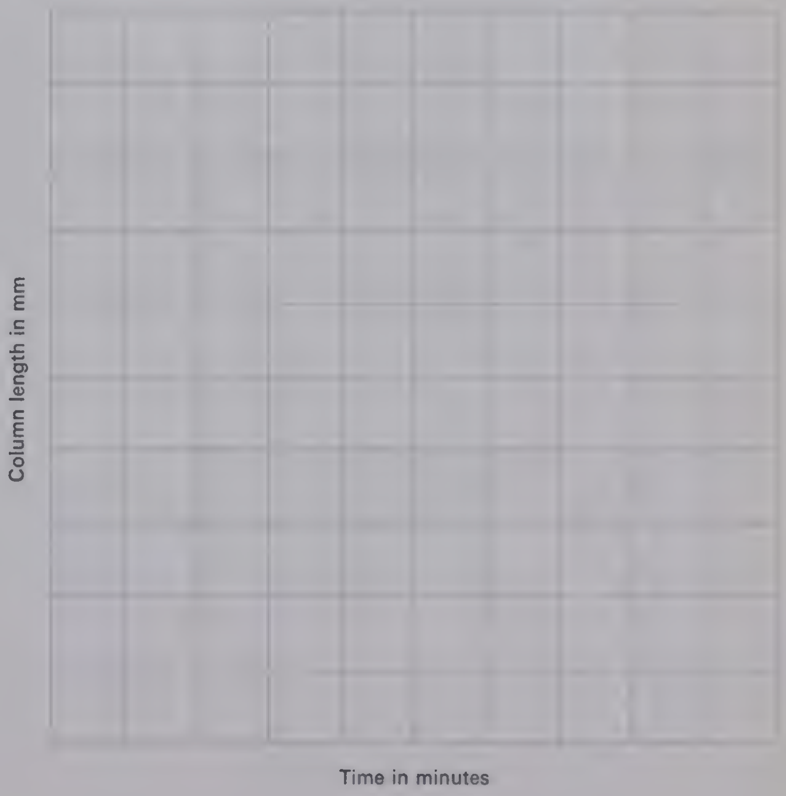
CAUTION: Follow your teacher's instructions on inserting glass tubing into the stopper.

Materials:

- 30-cm length of glass capillary tubing
- test tube
- one-hole stopper to fit test tube
- 250-ml beaker
- water
- candle
- metric ruler

Observations:

Elapsed time in minutes	Column length in mm



Questions:

1. What limitations prevent the general use of this thermometer as a temperature-sensing device?

2. Does the temperature (intensity of heat) seem to be related to the amount of heat that is put into an object (like the water thermometer)?

3. Why does the addition of heat cause the water to expand?

4. From your general experience can you identify other liquids that would be better than water for use in thermometers?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 5 4 page 105

Team Members ______________________________________

Problem: What happens to the temperature of a sample of ice as it is heated, melted, and finally boiled?

Hypotheses:

Attack: Place a sample of ice in a can and heat it with a moderate, steady source of heat. Take the temperature of the sample continuously and record the temperature at regular intervals until the water has boiled away. Prepare a graph from your results.

Materials:

- small metal can
- ringstand, ring, and asbestos pad
- thermometer
- stirring rod
- source of heat
- ice cubes
- paper towel or cloth

Observations:

Time in minutes	Temperature in °C.

Temperature in °C

Time in minutes

Questions:

1. What is the melting temperature for ice according to your experiment?

2. What is the boiling temperature for water according to your experiment?

3. Why might the values that you obtain be different from the accepted values for the melting and boiling points of water?

4. Is heat absorbed by water as it melts and boils? Which heat theory might explain where heat goes as water melts and boils?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________

Team Members ______________________________________

Supplementary
Experiment for
Chapter 5
(see p. 106)

Problem: Does the beginning temperature affect the freezing time of a water sample?

Hypotheses:

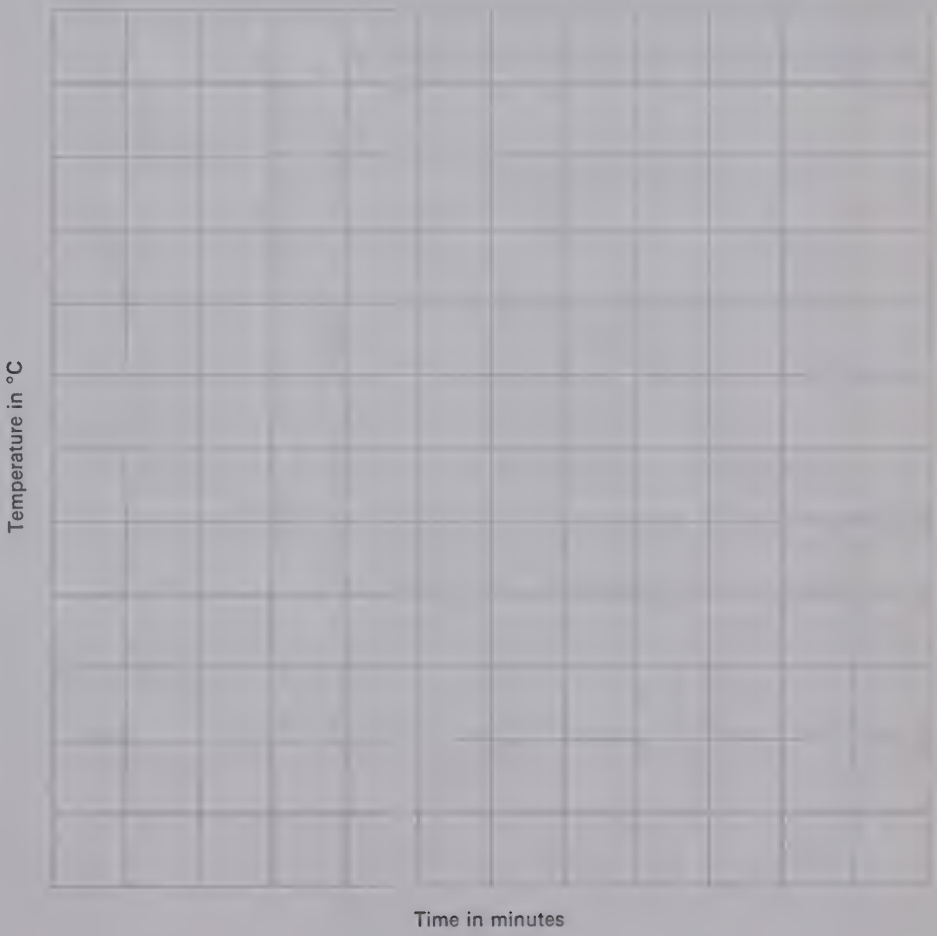
Attack: In freezing weather place samples of hot and cold water outdoors where they will cool and freeze. Observe and record the temperatures of the samples at regular time intervals. Prepare a graph from your results.

Materials:

- containers to hold water samples
- water samples at several initial temperatures that are above freezing
- thermometer for each sample

Observations:

Time in minutes	Temperature in °C



Questions:

1. Is this experiment in any way like Experiment 3–4 in which you observed a supersaturated solution of hypo?

2. How is the graph for the data of this experiment alike and different from the graph for Experiment 5–4?

3. Did you observe any evidence that indicated that your water samples were not pure water?

4. Are the hypotheses you stated for this experiment correct? Explain your thinking.

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________________ 5 5 page 109

Team Members ______________________

Problem: How will the time–temperature relationship change when the size of water samples to be heated is changed?

Hypotheses:

Attack: Use a heat source that gives a steady supply of heat. Apply the heat to water samples of several sizes and take the temperature of the samples at regular intervals. Use your results to prepare a graph.

Materials:

small metal can
ringstand, ring, and asbestos pad
thermometer
stirring rod
source of heat

Observations:

	Time in minutes	Temperature in °C
50-ml sample		
100-ml sample		

Questions:

1. What evidence does this experiment provide to indicate that the heat source does supply heat at a constant rate?

2. Suggest a method for measuring heat based on this experiment.

3. Does all heat go into the water sample? Explain.

4. Does the 100-ml sample of water require twice as much heat as the 50-ml sample to raise its temperature the same amount?

5. Predict where the line for a 200-ml sample of water would fall on your graph.

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 5 6 page 110

Team Members ____

Problem: Does the material of which a container is made affect the rate of cooling of the contents?

Hypotheses:

Attack: To each container add the same amount of boiling water. Trace the cooling of the water in each by using a thermometer. Record the temperature changes at regular intervals and use the data to prepare a graph.

Materials:

variety of containers
thermometer for each container
boiling water
graduated cylinder

Observations:

Time in minutes	Containers					

Temperature in °C

Time in minutes

Questions:

1. What materials seem to be good heat insulators?

2. What materials seem to be good heat conductors?

3. Does color affect the rate of loss of heat?

4. Explain the difference between an insulating substance and a conducting substance by using the caloric fluid theory.

5. Would the use of covers on the containers change the rate of heat loss?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 5 7 page 110

Team Members ______________________________________

Problem: How does the loss of heat compare with the loss of water from a leaking container?

Hypotheses:

Attack: Fill a milk carton with cold water; punch a small hole in the side of the carton at a point very close to the bottom. Use a ruler to measure the leakage rate at regular time intervals.

Materials:

- milk carton
- small nail
- metric ruler
- container to catch leakage
- water

Observations:

Time in minutes	Depth or volume change

Depth change or volume change

Time in minutes

Questions:

1. How does the graph for water loss compare with those for heat loss in the calorimeters?

2. If the hole were enlarged or a second hole of the same size were made, what would happen to the rate of water loss?

3. From your observations do you think that water loss and heat loss are similar?

4. What more can you say about the nature of heat and the nature of insulators and conductors?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 5 8 page 111

Team Members ______________________

Problem: If two quantities of water at quite different temperatures are mixed, what happens to the heat in them and what will be the final temperature?

Hypotheses:

Attack: By measuring the quantity of water in each sample and the change in temperature of each, when they are mixed, expressions for the amount of heat gained and heat lost can be obtained and compared.

Materials:

- 2 calorimeters
- 2 thermometers
- graduated cylinder
- hot and cold water

Observations:

Trial	Vol. of cold water	Temp. of cold water	Vol. of hot water	Temp. of hot water	Total vol.	Final temp.
	a	*b*	*c*	*d*	*e*	*f*

Calculations:

Trial	Change in temp. of cold water	Calories gained by cold water	Change in temp. of hot water	Calories given up by hot water
	$f - b$	$a(f - b)$	$d - f$	$c(d - f)$

Questions:

1. How does the heat lost compare with the heat gained?

2. Why would you do this experiment more than once before drawing any conclusions?

3. Predict the final temperature if 50 ml of cold water at 5°C were mixed with 100 ml of hot water at 95°C. Test your prediction by experiment.

4. What factors might lead to a consistent difference between the amount of heat lost and the amount gained?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 5 9 page 116

Team Members ______________________________________

Problem: What techniques can be used to trace the exchanges of heat as samples of hot and cold water are mixed?

Hypotheses:

Attack: Measure the mass and the temperature of quantities of hot and cold water before mixing and use these values to determine heat content and to predict a final temperature for the mixture.

Materials:

2 calorimeters
2 thermometers
graduated cylinder
balance
hot and cold water

Observations:

Trial	Calorimeter wt.	Hot water + calorimeter	Hot water temp.	Mixture + calorimeter	Mixture temp.	Cold water temp.
	a	b	c	d	e	f
1						
2						
3						
4						
5						
6						

Calculations:

Trial	Wt. of hot water	Heat of hot water	Wt. of cold water	Heat of cold water	Total heat	Wt. of mixture	Predicted final temp.
	$b - a$	$(b - a)c$	$d - b$	$(d - b)f$	$(b - a)c + (d - b)f$	$d - a$	$\frac{(b - a)c + (d - b)f}{d - a}$
1							
2							
3							
4							
5							
6							

Questions:

1. Why is the measurement of the water by mass a better measurement than by volume?

2. What explanations can you offer for why the observed temperature and the predicted temperature are different in some trials?

3. If differences exist between the predicted and actual final results, can you suggest explanations? Does the experimental technique seem to cause the difference?

4. Do your results indicate that heat is conserved?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 5 10 page 117

Team Members ______________________________________

Problem: Does heat play a part in the melting of ice? If so, is the amount of heat required a constant and predictable quantity?

Hypotheses:

Attack: Follow the same basic procedure as in Experiment 5–9, using ice instead of cold water for one sample. In addition try to identify the amount of heat in surplus of that necessary to warm water at 0°C to the final temperature. Then determine the amount of heat needed to melt one gram of ice.

Materials:

- 2 calorimeters
- 2 thermometers
- graduated cylinder
- balance
- ice
- hot and cold water

Observations:

Trial	Calorimeter wt.	Hot water + calorimeter wt.	Hot water temp.	Mixture and calorimeter wt.	Mixture temp.
	a	*b*	*c*	*d*	*e*
1					
2					
3					
4					
5					
6					

Calculations:

Trial	Wt. of hot water	Heat of hot water	Wt. of cold water (ice)	Wt. of mixture	Heat of mixture	Heat to melt ice	Heat to melt 1 g of ice
	$b - a$	$(b - a)c = G$	$d - b$	$d - a$	$(d - a)e = H$	$G - H$	$\frac{(G - H)}{(d - b)}$
1							
2							
3							
4							
5							
6							

Questions:

1. What average value do you get for the calories per gram of heat needed to melt ice?

2. Think about the freezing ice. What happens with respect to heat as the ice freezes?

3. How does the amount of heat needed to melt ice compare with the amount needed to heat the melted water from the freezing to the boiling point?

4. How well can the information of this experiment be fitted into the heat theories?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 5 11 page 118

Team Members ______________________________________

Problem: How do the heat capacities of other substances compare with the heat capacity of water?

Hypotheses:

Attack: Use a piece of material heated to a known temperature and then immersed in a known amount of cold water at a known temperature as a way of getting data on the exchange of heat between the hot sample and the cold water. Repeat this procedure with each sample.

Materials:

samples of metals and other substances
calorimeter
2 thermometers
cold water
container of boiling water

Observations:

	Trials					Units
Data identification	1	2	3	4	5	
Kind of substance						
Volume of sample (a)						ml
Mass of sample (b)						g
Temp. of hot sample (c)						°C
Mass of cold water (d)						g
Initial temp. of cold water (e)						°C
Final water temp. (f)						°C

Calculations	1	2	3	4	5	Units
Temp. change of water $(f - e)$						°C
Heat gained by water $d(f - e)$						cal
Temp. change of sample $(c - f)$						°C
Heat loss per ml of sample $\frac{d(f - e)}{a}$						cal/ml
Heat loss per ml per °C by sample $\frac{d(f - e)}{a(c - f)}$						cal/ml °C
Heat loss per g of solid $\frac{d(f - e)}{b}$						cal/g
Heat loss per g per °C of sample $\frac{d(f - e)}{b(c - f)}$						cal/g°C

Questions:

1. How do the heat capacities of other substances compare with the heat capacity of water?

2. Does the heat capacity of a substance seem to be related to its density?

3. Does the state of matter influence its ability to hold heat?

4. Relate the idea of heat capacity to your theories for the structure of matter and the nature of heat.

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 6 1 page 127

Team Members ____

Problem: Does heating cause a loss in mass for a sample of gas?

Hypotheses:

Attack: Place two sealed flasks on opposite arms of a two-pan balance and adjust the balance so that static equilibrium exists. Heat one of the flasks with a heat lamp to see if this upsets the equilibrium.

CAUTION: Do not heat the flask excessively; the stopper could be blown out.

Materials:

- two-pan balance
- 2 flasks
- 2 one-hole stoppers
- 2 thermometers
- heat lamp

Observations:

Questions:

1. Are your observations in agreement with those of your classmates?

2. If heating a gas sample changes its mass, what do you think would happen if you cooled the gas sample? Test your prediction.

3. If heat does show itself by reducing the observable mass of a gas sample, would you expect the same effect with solids and liquids?

4. Why is it important to use sealed flasks?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ________________ 6 2 page 128

Team Members ______________________________________

Problem: What is the relationship between the volume and the temperature of a sample of gas?

Hypotheses:

Attack: Seal one end of the glass tubing by heating it. While the tube is still warm, dip the open end into a droplet of mercury so that a small bit of the mercury can enter the tube and become a free moving piston.

Bind the tube, a metric scale, and a thermometer together and insert them into ice water. Then gradually warm them from near 0°C to about 60°C.

Materials:

glass tubing, 20 cm by 2 mm (inside diameter)
thermometer
20-by-150-mm test tube
beaker
heat source
metric scale

Observations: (Record the length of the gas sample and the temperature every few degrees of temperature change.)

Temperature	Column length

Column length

Temperature

Questions:

1. How much did the volume change between 10°C and 20°C? between 20°C and 30°C? between 50°C and 60°C?

2. On a separate sheet of graph paper plot your results using the Kelvin scale instead of the Celsius scale. Extend the line of your plot until it intersects the temperature axis. What is the significance of this point of intersection?

3. What would you predict as a result if a gas other than air were used in the tube?

4. Why do you think gases change volume so much more than solids and liquids?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________

Team Members ______________________________________

Problem: What can be learned about gases by studying the diffusion of one gas into another?

Hypotheses:

Attack: Allow a detectable gas or gases to diffuse down a long glass tube. Keep a record of the time needed for the gas or gases to move an observable distance in the tube. If possible vary the temperature and position of the tube.

Materials:

glass tube, 50 or more cm long, 2 cm in diameter
2 stoppers to fit the test tube
2 droppers
thermometer
small quantities of hydrochloric acid and ammonia

Observations:

Trial	1	2	3	4	5	6
Temperature						
Distance traveled by ammonia						
Distance traveled by acid						
Time required						
Tube position						
Percent of total distance traveled by the acid						
Percent of total distance traveled by ammonia						
Rate for the acid						
Rate for ammonia						

Questions:

1. Is diffusion rate related to temperature?

2. Does the position of the tube affect the diffusion rate?

3. Do the two gases travel down the tube the same distance in the same period of time?

4. Does a change in temperature cause a change in the way the rates for the two gases compare?

5. Can a caloric fluid theory effectively explain the diffusion of gases?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________________

Team Members ______________________

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Problem: What further evidence, in addition to diffusion, can be collected that indicates motion of gas particles?

Hypotheses:

Attack: Obtain or build a small chamber for containing smoke particles. The chamber should be lighted from the side so that light will reflect from the particles into the objective lens of the microscope used for viewing.

Materials:

- chamber
- microscope
- strong light source
- magnifier
- matches or other source of smoke

Observations:

Questions:

1. Compare your observations in this experiment to those of Experiment 6–3.

2. How do the smoke particles compare in size to the gas particles?

Conclusions and suggestions for further investigations:

Supplementary
Experiment for
Chapter 6
(see p. 138)

Reporter ______________________ Date ______________

Team Members ______________________________________

Problem: How does the diffusion rate of carbon dioxide compare with that of other gases?

Hypotheses:

Attack: Place a source of carbon dioxide at the bottom of a beaker or a tall cylinder. (Dry ice is best, but marble chips in hydrochloric acid may be used.) Use a glowing splint to trace the arrival of the carbon dioxide at the mouth of the container. Keep a record of the time needed for the gas to travel up the container.

Materials:

glass tube, 50 or more cm long, 2 cm in diameter
source of carbon dioxide
wooden splints

Observations:

Questions:

1. Does the vertical position of the tube affect the results?

2. If dry ice is used, can you take the effect of temperature into account?

3. Does this experiment give you a basis for comparing the particle weight of hydrochloric acid gas, ammonia gas, and carbon dioxide gas?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 7 1 page 146

Team Members ____________________________________

Problem: What factors other than heat affect the evaporation rate of a liquid?

Hypotheses:

Attack: Place equal amounts of water in the test tube and beaker. Set them aside in a quiet place and let the water evaporate. Put equal amounts of water in two more beakers. Blow air over one with a fan and let the other sit undisturbed. Observe the evaporation rate in all four containers.

Materials:

20-by-150-mm test tube
3 250-ml beakers
fan or other source of air current
test tube rack

Observations:

Questions:

1. Is there a process that is the opposite of evaporation? If so, can its rate be changed and would such changes affect evaporation?

2. Does this experiment contain evidence favoring a particle motion theory?

Conclusions and suggestions for further investigations:

7
2
page 152

Reporter ____________________ Date ____________

Team Members ____________________________________

Problem: Does the boiling temperature depend upon the air pressure above a liquid?

Hypotheses:

Attack: Boil the water in an open flask for a minute or so to allow it to fill with water vapor. Remove the heat source and seal the flask with a stopper that has a thermometer mounted in it. Invert the flask and run cold water over it.

CAUTION: Handle the flask very carefully. If scratched or bumped it can *implode* and then explode.

Materials:

- 250-ml round bottom flask
- one-hole stopper to fit flask
- thermometer
- ringstand, ring, and asbestos pad
- test tube clamp
- source of heat
- toweling to use as a hot pad

Observations:

Questions:

1. Does equilibrium exist at any time inside the flask?

2. Does this experiment supply evidence for particle motion or for caloric fluid?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 7 3 page 152

Team Members ______________________________________

Problem: Is it possible to observe evidence of particle motion in liquids similar to that observed for gases?

Hypotheses:

Attack: Observe a drop of very dilute milk under a microscope for motion in the visible milk particles.

Materials:

microscope
glass slide
cover slip
drop of diluted milk
strong light source

Observations:

Questions:

1. What similarities and differences did you observe between the particle motion in the milk drop and the particle motion in the gas chamber used in Experiment 6–4?

2. Use your observations in this experiment to explain why some substances remain suspended in a liquid and why others settle out.

Conclusions and suggestions for further investigations:

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4
page 152

Reporter ______________________ Date ______________

Team Members ____________________________________

Problem: What effect does temperature have on the rate of diffusion of a solute into a solvent?

Hypotheses:

Attack: Drop one crystal each of potassium permanganate into the bottom of two tall containers, one with hot water and the other with cold water. Observe the rate of diffusion into the water in each container.

Materials:

4 20-by-150-mm test tubes
2 one-hole stoppers to fit test tubes
2 droppers
2 solid stoppers to fit test tubes
small pieces of double-sticky tape
crystals of potassium permanganate
bottle of ink

Observations:

Questions:

1. Why would high temperatures produce more rapid diffusion than low temperatures?

2. Is this experiment consistent with the particle motion theory?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 8 1 page 160

Team Members ______________________________________

Problem: What ability do we have to sense radiation directly without the aid of instruments or our eyes?

Hypotheses:

Attack: While blindfolded, attempt to detect sources of radiation. Let a classmate bring a variety of sources of radiation near your hand or your face to see if you can tell whether it is there.

CAUTION: It is best for you to stand or sit still while your partner brings the items to be tested near you.

Materials:

- sources of radiant energy: incandescent and fluorescent light bulbs, a hot iron, a can of hot water, a can of ice water, direct sunlight, and a candle
- cloth for the blindfold
- meter stick

Observations: Record the distance between radiator and sensing point when detection occurs.

Point of sensitivity	Source of radiation						
	Incandescent lamp	Fluorescent lamp	Iron	Candle flame	Hot water	Cold water	Sunlight
Forehead							
Lips							
Cheek							
Palm of hand							
Back of hand							
Inner wrist							

Questions:

1. Which areas of the body are best equipped to detect radiation?

2. Are you equipped to be a good radiation detector?

3. Are you a source of radiation?

Conclusions and suggestions for further investigations:

8
2

page 160

Reporter ____________________ Date ____________

Team Members ______________________________

Problem: Is it possible to construct a simple, easy-to-build device that is very sensitive to radiation?

Hypotheses:

Attack: Assemble an apparatus that traps two quantities of air connected by a tube of liquid. The two air quantities should be separated and shielded so that the potential radiation source can be brought near one without affecting the other.

Materials:

- U-shaped glass tubing, 6 mm in diameter
- 2 small test tubes
- 2 one-hole stoppers to fit test tubes
- large corrugated cardboard box
- heat shield (such as a piece of corrugated cardboard)

Observations:

Questions:

1. Would the size of the test tubes influence the sensitivity of a differential air thermometer?

2. Is it essential for the thermometer to have two trapped quantities of air or could one end be open?

Conclusions and suggestions for further investigations:

page 162

Reporter ______________________ Date ______________

Team Members ______________________________________

Problem: Does the temperature of an object affect its radiation rate?

Hypotheses:

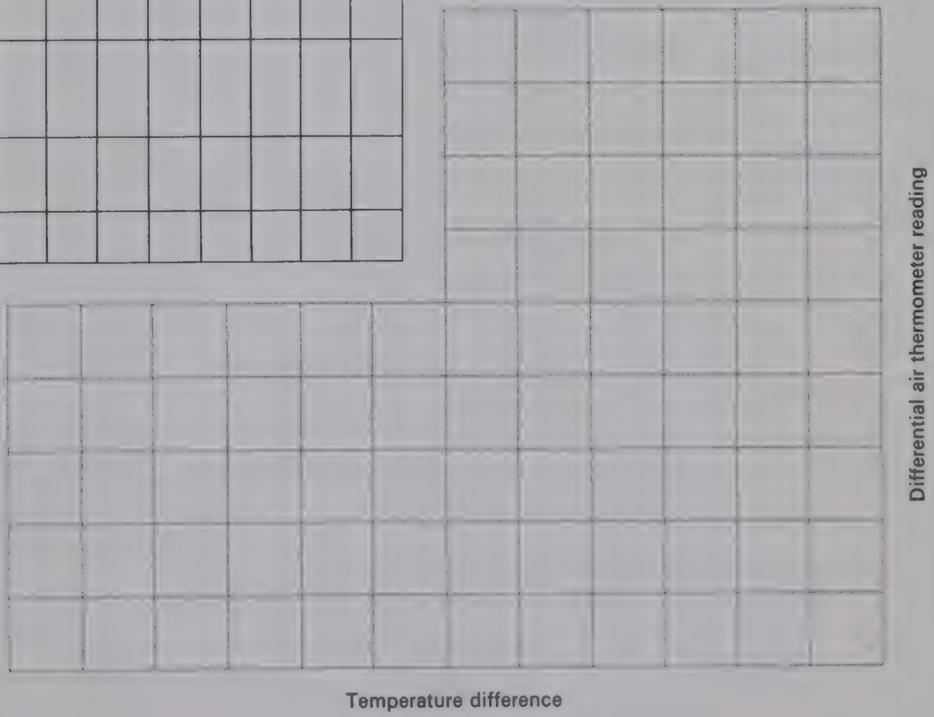
Attack: Use the differential air thermometer as a radiation detector in a study of radiation from containers of hot and cold water.

Materials:

differential air thermometer
2 similar containers
2 thermometers
candle
aluminum foil
metric scale
supports for containers

Observations:

Trial	1	2	3	4	5	6	7	8	9	10
Hot water temp.										
Cold water temp.										
Temp. difference										
Thermometer scale reading										
Container distance from thermometer bulb										
Temp. of water in container										
Thermometer scale reading										



Questions:

1. Are any materials both good radiators and good insulators?

2. Is there any evidence that cold objects radiate heat?

3. What effect does distance have on the radiation that reaches the bulb of the differential air thermometer?

4. Does either the particle motion theory or the caloric fluid theory provide a means for explaining radiation?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 8 4 page 164

Team Members ______________________________________

Problem: To test the effects of radiation conditions on plants.

Hypotheses:

Attack: Plant pieces of potato under a variety of radiation conditions. Keep other conditions as constant as possible. Observe the seedlings over a period of several weeks to see if there are variations in coloration and rate of growth.

Materials:

3 beakers or plastic cups
2 large cans, one with a transparent cover
2 glass jars, quart-sized or larger
potato
large two-hole stopper to fit glass jar
aquarium

Observations:

Questions:

1. What are the apparent differences between the plant that received light and those that did not?

2. Could plants survive with heat radiation only?

3. Could plants survive with light radiation only?

4. How does this experiment show that radiation interacts with matter and possibly becomes a part of matter?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 8 5 page 165

Team Members ______________________________________

Problem: Under what light conditions do algae grow in an aquarium?

Hypotheses:

Attack: Cover all but one side of your aquarium with opaque paper or paint. On the remaining side put strips of colored cellophane so that the type of light entering the aquarium can be controlled.

Materials:

aquarium (could be a quart jar)
cellophane, several colors
opaque paper or paint
algae to seed the aquarium

Observations:

Questions:

1. What is the most obvious condition that causes variation in the growth of the algae?

2. What conditions are necessary for algae to grow?

3. What color light allows the algae to grow the best?

4. Does the depth of the water influence the growth of the algae?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 8 6 page 166

Team Members ____

Problem: Can radiation be converted to mechanical motion?

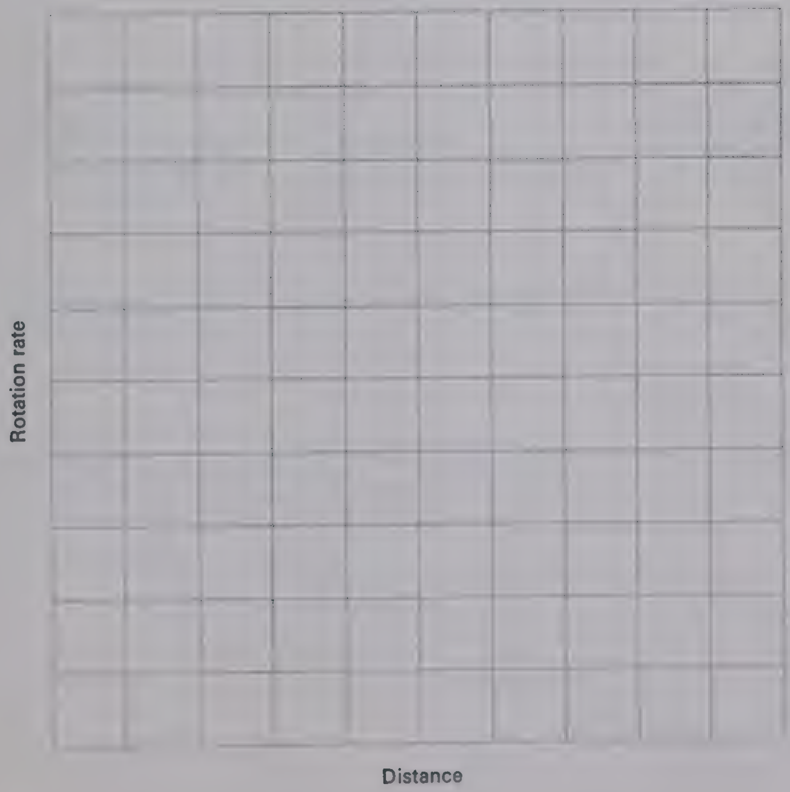
Hypotheses:

Attack: A radiometer should be sensitive enough to show a mechanical response to radiation. Bring one near a light source and observe its response. Note the distance and the effect of the intensity of the source on the action of the radiometer.

Materials:

- radiometer
- electric lamp
- light bulbs of a variety of wattages
- reflectors for the lamp
- meter stick

Observations:



Questions:

1. Are your hypotheses for this experiment confirmed by the experiment? Explain.

2. Explain the relation between rotation rate of the radiometer and distance from a light source.

3. What two factors seem to affect the rate of rotation of the radiometer?

4. Is the radiometer sensitive to heat radiations as well as light radiations?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 9 1 page 173

Team Members ______________________________________

Problem: What work is done in lifting an object?

Hypotheses:

Attack: Suspend a 1.0-kilogram mass from a spring balance, then lift it through measured distances.

Materials:

- 1.0-kilogram mass
- spring balance
- meter stick

Observations:

Questions:

1. How many different combinations of mass and distance could be used in doing 2.0 kgf-m of work?

2. What work is done if 150 kg are lifted through a distance of 5 meters?

3. What energy is released as a 150-kg mass falls back the 5 meters to its original position?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 9 2 page 176

Team Members ______________________________________

Problem: What is happening to the energy in a system as a pendulum swings back and forth?

Hypotheses:

Attack: Set up a simple pendulum and set it in motion. Observe its action carefully. Insert an obstruction so that the length of string that is moving is changed.

Materials:

one-hole rubber stopper
length of string
pencil
chalkboard or other surface on which to mark the motion of the pendulum
piece of chalk

Observations: A sketch would be a good way to record your observations. Label it clearly.

Questions:

1. If the stopper has a mass of 0.1 kg, how much potential energy does it have at the highest point in its swing as compared with the lowest point in its swing?

2. What effect does the insertion of an obstruction have on the rise and fall of the stopper?

3. Can you account for the energy in the system at all stages of the cycle?

4. Does this experiment support the idea that energy is conserved?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 9 3 page 178

Team Members ____

Problem: Can more energy or work be obtained from a lever system than is put into it?

Hypotheses:

Attack: Set up a lever system and balance it with a 100-g mass on one side of the fulcrum and a 200-g mass on the other side. Move one side up or down. Measure the distance moved by each mass as they move and calculate the change in potential energy for each.

Materials:

meter stick
piece of strong thread
100-g mass
200-g mass
500-g mass

Observations: A carefully prepared sketch of the apparatus in which the masses, distances moved, and lever arm lengths are shown is the ideal form to use for recording this experiment.

	Trials					
	1	2	3	4	5	Units
Location of fulcrum						cm
Mass to left of fulcrum	200					g
Location of mass to left of fulcrum	20					cm
Mass to right of fulcrum	100					g
Location of mass to right of fulcrum						cm
Vertical distance moved by left mass d_1						cm
Lever arm of left mass ℓ_1						cm
Vertical distance moved by right mass d_2						cm
Lever arm of right mass ℓ_2						cm
Work done by or on left mass						gfm
Work done by or on right mass						gfm
Ratio of lever arms $\frac{\ell_1}{\ell_2}$						
Ratio of distances $\frac{d_1}{d_2}$						
Inverse ratio of masses $\frac{m_2}{m_1}$						

Questions:

1. Is energy conserved in this lever system?

2. How do the ratios of lever arm lengths, distances, and masses compare?

3. How can the lever system be used to determine an unknown mass?

4. What is the source of the force that acts and causes work to be done as the masses move in this experiment?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 9 4 page 184

Team Members ______________________________________

Problem: What portion of the work put into an elastic object will it return upon release?

Hypotheses:

Attack: Suspend a dowel between two chairs or two tables. One by one hang 100-g masses from the center of the dowel. Measure the distortion distance of the dowel after the addition of each new mass increment. Then start removing the masses one by one, reading the change in distortion of the dowel after each mass is removed. Repeat this procedure with the dowel clamped to a table edge and loaded at the other end.

Materials:

- dowel, 6 mm in diameter, 60 cm long
- 30-cm length of string
- meter stick
- 5 100-g masses
- clamp or a stack of books for support

Observations:

Distance between supports ____ cm		
Masses added		
Force applied	Scale reading	Total distortion
0 gf		
100 gf		
200 gf		
300 gf		
400 gf		
500 gf		
Masses removed		
Force applied	Scale reading	Total distortion
500 gf		
400 gf		
300 gf		
200 gf		
100 gf		
0 gf		

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Questions:

1. What explanation can you offer for the distortion differences between addition and removal of masses from the dowel?

2. How elastic is a wooden dowel?

3. Could a flexible wooden beam be calibrated and used as a weighing device?

4. Does this experiment support the idea of conservation of energy?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________________ 9 5 page 186

Team Members ____

Problem: Is a rubber band more elastic than a wooden dowel?

Hypotheses:

Attack: Gradually load a heavy duty rubber band with 100-g masses. Record the amount of distortion each time that another mass is added. Once fully loaded, remove the masses one at a time and promptly note and record the remaining distortion.

Also look for evidence of change in temperature as a rubber band is flexed and released.

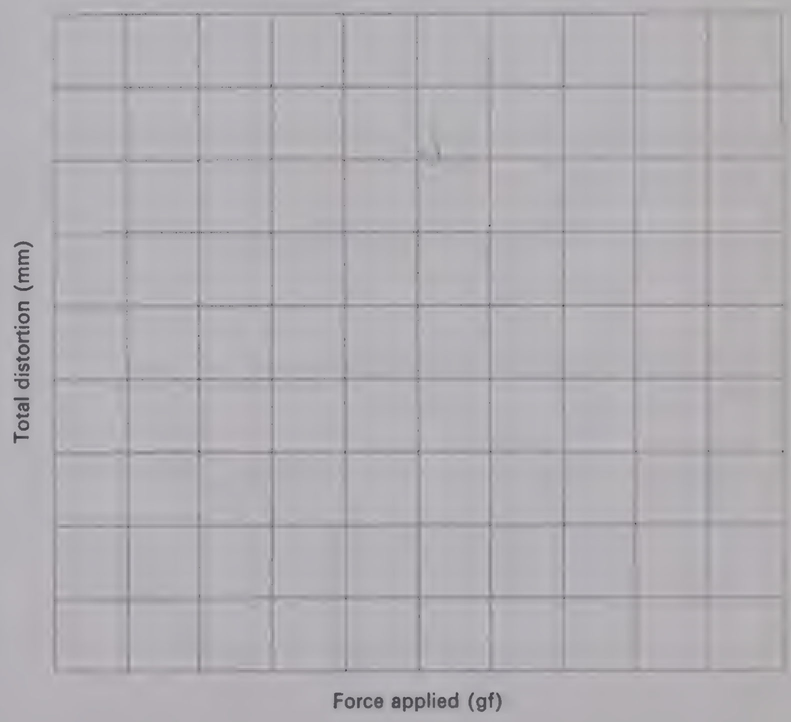
Materials:

heavy-duty rubber band (3–4 mm wide)
five 100-g masses
support for the rubber band
meter stick

Observations:

Masses added		
Force applied	Scale reading	Total distortion
gf	mm	mm

Masses removed		
Force applied	Scale reading	Total distortion
gf	mm	mm



Questions:

1. How does the elasticity of rubber in a rubber band compare with the elasticity of wood?

2. Wood and rubber, as pieces of matter, can be made of particles according to one of our theories. When they are distorted, some particle motion occurs. Could this be an explanation for the difference in energy put in and energy that comes out of the rubber band and the dowel?

3. Would a piece of rubber become more elastic or less elastic if it were chilled or warmed?

4. From your experience with this experiment and Experiment 9–4, devise a definition for the word *elastic*.

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________________

Team Members ____

Problem: Is there a relationship between motion energy and heat?

Hypotheses:

Attack: Rub wood and sandpaper together. Continue until an obvious rise in temperature occurs.

Materials:

blocks of wood, 1″ by 3″ by 6″
piece of fairly coarse sandpaper
thermometer

Observations:

Questions:

1. Can motion energy be converted to heat?

2. The experiments of this chapter deal with the links connecting radiations, mechanical motion, and heat. As a result of your experience, can you accept all of these as forms of energy?

3. Use the particle motion theory to describe what happens as friction produces heat.

4. Can the caloric fluid theory be used to describe the effects of friction?

Conclusions and suggestions for further investigation:

Reporter ______________________ Date ______________ 10 1 page 196

Team Members ______________________________________

Problem: What relationship exists between the strength of a magnetic field and the distance from the pole of the magnet?

Hypotheses:

Attack: Pick up a pile of filings with one card and drop it on a piece of paper. Add a second card and pick up another pile of filings. Continue until a ten card thickness is reached.

Materials:

long slender bar magnet
several file cards, 3 cm on each side
double-sticky tape
30–40 g of iron filings
2 pieces of white paper

Observations:

Trial	Distance from magnet	Mass of filings

Questions:

1. How does the magnetic field strength change with distance?

2. Does your graph give you any clues as to the distance at which the force is zero?

3. Is there any evidence that the iron filings act as magnets?

4. How can you relate this experiment to the other studies of energy that you have done?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 10 2 page 198

Team Members ______________________________________

Problem: What is the nature of a magnetic field?

Hypotheses:

Attack: Place a bar magnet under a large sheet of stiff paper. Prop the paper around the magnet with pieces of cardboard. Sprinkle iron filings on the paper, then tap the table to get the filings oriented. Spray with plastic varnish to fix the filings in place.

Materials:

- 2 long, slender bar magnets
- 2 large sheets of heavy paper, 18″ by 24″
- iron filings
- spray can of clear varnish
- can fast-drying paint

Observations:

Questions:

1. What general quality do you find to be common to all the field patterns you have prepared?

2. What happens to the fields when two magnets are brought close together?

3. What is an equipotential line in a magnetic field?

4. How does the shape of a magnet influence the field pattern?

5. Is there any evidence that the field lines converge at a point within the magnet?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 10 3 page 201

Team Members ______________________________________

Problem: What other techniques can be used to reveal information about magnetic fields?

Hypotheses:

Attack: Trace the position of a bar magnet on a sheet of paper. Then move a small compass, starting at one end, and marking the position of the needle through a series of positions from one end of the magnet to the other. Draw a continuous line through the dots at each compass position. Repeat this procedure until you have created a network of lines around the magnet.

Materials:

bar magnet
small compass

Observations:

Questions:

1. Where is the pole of a magnet located as indicated by this experiment?

2. Is a magnetic field confined to a plane?

Conclusions and suggestions for further investigations:

10
4
page 201

Reporter ______________________ Date ______________

Team Members ______________________________________

Problem: How will the motion of one magnet affect another magnet near it, but not touching it?

Hypotheses:

Attack: Hang two magnets with the thread on the meter stick. The magnets should hang horizontally and yet be free to swing. When they come to rest, deliberately move one magnet in various ways to see what response occurs in the other one.

Materials:
2 bar magnets
meter stick
60-cm of thread

Observations:

Questions:

1. Does this experiment contribute to your understanding of the force field around a magnet?

2. What would happen if you were to hang a dozen or more magnets in a row and then twist one at the end of the row?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 10 5 page 202

Team Members ______________________________________

Problem: Is there any connection between magnetism and electric current?

Hypotheses:

Attack: Connect a coil of wire to the dry cell. While the wire is connected explore around the coil with a small compass (or a magnet that is free to swing). Break the circuit and see what happens to the needle of the compass.

Materials:

- coil of insulated no. 28 copper magnet wire, containing 200 or more turns
- flashlight dry cell
- small compass

Observations:

Questions:

1. Does it seem that an electric current is accompanied by a magnetic field?

2. Could a magnetic field be used to produce an electric field and an electric current?

3. Does it appear that there is a relationship between the direction of current flow and the polarity of the associated magnetic field?

Conclusions and suggestions for further investigations:

10
6

page 203

Reporter ______________________ Date ______________

Team Members ______________________________________

Problem: Do fields, similar to magnetic fields, seem to exist around electrically charged objects?

Hypotheses:

Attack: Rub the strips or loops of plastic with a piece of wool or fur. Observe the results. Bring other rubbed and unrubbed strips near the first strip. Rub a toy balloon and bring it near the rubbed strip.

Materials:

- strips or loops from a plastic garment bag
- piece of wool or fur
- toy balloon

Observations:

Questions:

1. Does more than one kind of charge seem to exist?

2. Does this experiment seem to indicate that all matter can become electrically charged?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 10 7 page 206

Team Members ____

Problem: What can a vacuum tube electroscope reveal about electric charges?

Hypotheses:

Attack: Connect the electroscope so that it is operational. Then bring various objects, charged and uncharged, near the antenna. Observe what happens to the lamp. Test the distance at which a charged object will affect the lamp when you wave the object around.

Materials:

vacuum tube electroscope
plastic strip
piece of wool or fur

Observations:

Questions:

1. What kinds of materials collect and hold electric charges?

2. From your experience with electric current and static charges, are you willing to accept the idea that all matter is electrical?

3. Can electric fields act at different distances?

4. We have now accepted the particle theory for matter. What does this experiment suggest about the nature of particles?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________________ 10 8 page 209

Team Members ______________________

Problem: Can electric charge be isolated on a piece of conductive material?

Hypotheses:

Attack: Suspend a square of aluminum foil by a thread. Bring it near a piece of charged plastic while your fingers are on the foil. Quickly release your hold on the foil and pull it away from the charged plastic. Then test the foil with the electroscope to see if it is charged.

Materials:

- 20-cm square of aluminum foil
- small strip of aluminum foil
- piece of plastic
- piece of wool or fur
- vacuum tube electroscope
- thread

Observations:

Questions:

1. How does the electric field around a charged object change with distance?

2. What is electrical induction? What relation does it have to the action of the vacuum tube electroscope?

3. What properties can you assign to particles of matter as a result of studying Chapter 10?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 11 1 page 220

Team Members ______________________________________

Problem: What kinds of changes are evident in a chemical reaction?

Hypotheses:

Attack: Put a nail in a copper sulfate solution and measure any temperature change. Note any other changes. Repeat the experiment with a piece of zinc.

Materials:

- test tube
- test tube rack
- iron nail
- copper sulfate solution
- piece of zinc
- thermometer

Observations:

Questions:

1. What changes indicate that a chemical reaction occurred when the iron nail was placed in copper sulfate solution?

2. Does this chemical reaction release heat or absorb it?

3. What differences are apparent between the reaction of the iron and the zinc with copper sulfate solution?

4. How could you set this reaction up to detect release of electrical energy?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________________ 11 2 page 220

Team Members ____

Problem: Is electrical energy released during chemical reaction?

Hypotheses:

Attack: Two metals, each in contact with a solution of one of its compounds, can be connected by a solution bridge and by wires through a vacuum tube electroscope. Use such a system to attempt to observe electricity in relation to chemical reaction.

Materials:

2 250 ml beakers
1-by-10-cm strip of copper
1-by-10-cm strip of zinc
2 wires with alligator clips
vacuum tube electroscope or voltmeter
200 ml of zinc nitrate solution
200 ml of copper sulfate solution
50 ml of ammonium nitrate solution
rolled-up paper towel

Observations:

Questions:

1. What conditions must exist for current to be evident and for reaction to occur?

2. Does either plate affect the vacuum tube electroscope?

3. How does this arrangement separate the parts used in Experiment 11–1?

4. A chemical change modifies the condition of the substance involved. Relate this statement to the particle theory for matter.

Conclusions and suggestions for further investigations:

Reporter ________________________ Date ________________ 11 3 page 222

Team Members ____

Problem: Do liquids conduct an electric current?

Hypotheses:

Attack: Set up a flashlight so that a complete circuit does not exist unless a current flows across a liquid. Test various liquids, solvents, and solutions for conductivity.

Materials:

- conductivity testing device complete with lamp and dry cells
- 10 250-ml beakers
- 100-ml quantities of alcohol, tap water, and distilled water
- 100-ml quantities of solutions of copper sulfate, zinc nitrate, ammonium nitrate, sodium chloride, sugar, and acetic acid (concentrated and dilute)

Observations:

Questions:

1. Why should both probes of the conductivity tester be made of the same metal?

2. What seems to make a good electrolyte?

3. Does the solvent have to be water for the solution to be an electrolyte?

4. What kind of particles exist in electrolytes compared to non-electrolytes?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________________ 11 4 page 227

Team Members ____

Problem: Do some chemical reactions absorb heat as they take place?

Hypotheses:

Attack: A reaction that does not involve energy in an obvious way as it occurs is the reaction of Alka Seltzer in water. Study this reaction closely by dissolving a tablet in a measured amount of water and checking whether the water temperature changes during the reaction.

Materials:

- beaker
- mortar and pestle
- thermometer
- water
- Alka-Seltzer tablets

Observations:

Questions:

1. What evidence for chemical reaction is apparent in this experiment?

2. What change in temperature occurs? Why?

3. How is the dry residue from the reaction different from the original tablet?

4. Can you relate this reaction to the particle motion theory?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________________ 11 5 page 230

Team Members ______________________

Problem: What factors affect the corrosion of metals?

Hypotheses:

Attack: Place one ball of steel wool in one jar; one ball in another jar. Put one under moist conditions and the other under dry conditions. In the second pair of jars, place the pieces of silverware. In one of these jars introduce a means of producing hydrogen sulfide gas and in the other keep the air clean and dry.

Materials:

4 quart-sized jars with lids
2 balls of steel wool
2 pieces of silverplated flatware
10 ml of concentrated sulfuric acid
5 g of ferrous sulfide
several pieces of string
50 ml of water

Observations:

Questions:

1. Is there any evidence of corrosion in the four jars?

2. Have you ever smelled the gas produced in the ferrous sulfide jar before? Where?

3. Do these reactions seem to be spontaneous?

4. How can the particle motion theory be used to describe what happens in the jars?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 11 6 page 232

Team Members ____

Problem: How is reaction rate affected by temperature?

Hypotheses:

Attack: Measure reaction rate for a particular reaction at many different temperatures. (Each team should use a different temperature.)

Materials:

- 250-ml beaker
- thermometer
- Alka-Seltzer tablet
- 100-ml quantities of water at a variety of temperatures

Observations:

Trial	1	2	3	4	5	6	7	8	9	10	Unit
Initial temp.											°C
Reaction time											sec
Final temp.											°C
Average reaction temp.											°C

(1) Initial water temperature (°C)

(2) Final water temperature

(3) Average water temperature

Questions:

1. Does it make any difference whether the initial, final, or average temperature is used in plotting?

2. What general statement about the effect of temperature on reaction rate can you make for this reaction?

3. Does the amount of gas released seem to vary with the temperature?

4. Predict what would happen if you dropped a second, third, and fourth Alka-Seltzer tablet into a beaker, or if you dropped in several tablets at once.

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 11 / 7 page 233

Team Members ______________________________________

Problem: What effect does concentration have on reaction rate?

Hypotheses:

Attack: Choose a reaction in which the concentration of one of the ingredients can be varied quite readily while the other one is held constant. Carry out the reaction at a number of concentrations.

Materials:

- 2 small test tubes (13 × 100 mm)
- 8 2-cm lengths of magnesium ribbon
- a dropper
- two thermometers
- test tube rack
- graduated cylinder
- dilute hydrochloric acid
- water

Observations:

Trial	1	2	3	4	5	6	7	8	9	10	
Concentration of acid											drops per 10 ml
Dissolving time											sec
Acid Temperature											°C
Metal strips added											

Questions:

1. What effect does the concentration of the acid have upon the reaction rate?

2. What happens to the reaction rate as successive pieces of metal are added?

3. What change in temperature occurs? Does it seem to be related to rate of reaction and thus to concentration in this reaction?

4. Can you use a particle motion theory to construct a mental picture of what happens in this reaction?

Conclusions and suggestions for further investigations:

Reporter ____________________ Date ____________________ 11 8 page 235

Team Members ____

Problem: What effect does surface area have on reaction rate?

Hypotheses:

Attack: Determine the time for a broken Alka-Seltzer tablet to react completely as compared with the reaction time for an unbroken tablet. Deliberately vary the amount of exposed surface.

Materials:

- 3 Alka-Seltzer tablets
- mortar and pestle
- 250-ml beaker
- water

Observations:

Questions:

1. Can you relate this experiment to building a campfire or a fire in a fireplace?

2. We usually think of surface area in relation to solids. Do liquids and gases have a surface area (when considering chemical reactions)?

3. Is the surface area related to concentration as a factor affecting the rate of reaction?

4. How can the particle theory be used to explain the effect of surface area on reaction rate?

Conclusions and suggestions for further investigations:

Reporter ____________________ Date ____________________ 11 9 page 235

Team Members ____________________

Problem: Will other substances than those that react influence the rate of reaction?

Hypotheses:

Attack: Compare the rate at which hydrogen peroxide decomposes when in the presence of various substances to its rate of decomposing with no substances present.

Materials:

- 6 test tubes
- test tube rack
- 30 ml of 3% hydrogen peroxide solution
- tiny quantities of manganese dioxide, copper metal, zinc metal, sodium chloride, calcium carbonate.

Observations:

Questions:

1. Is there any noticeable reaction of hydrogen peroxide when a catalyst is not present?

2. Why is the sixth test tube of hydrogen peroxide solution used as a control?

3. Is the catalyst changed by the reaction? How can you answer this question without experimenting?

4. How can catalysts be described using the particle theory?

Conclusions and suggestions for further investigations:

Reporter ____________________ Date ____________________ 11 10 page 236

Team Members ____

Problem: Can the equilibrium state of a chemical reaction be altered by adding energy?

Hypotheses:

Attack: Apply electric current to a solution of sulfuric acid and water to see if the solution is changed by the current.

Materials:

- 2 20-by-150-mm test tubes
- 250-ml beaker
- 2 electrodes
- dilute sulfuric acid
- water
- source of direct electric current
- wire and clips

Observations:

Questions:

1. Why do you think the electrical energy causes this reaction to occur?

2. How does the quantity of hydrogen gas compare with that of oxygen? Explain.

3. Use the particle theory to describe this reaction.

4. Why does sulfuric acid make the water a good conductor?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________ 11 11 page 238

Team Members ______________________

Problem: Can an equilibrium condition be produced in a chemical reaction by controlling the conditions of reaction?

Hypotheses:

Attack: Drop one Alka-Seltzer tablet in each bottle. Screw one cap on tightly and leave the other open.

Materials:

- 2 small cylindrical containers with caps
- transparent adhesive tape
- 2 Alka-Seltzer tablets
- timer
- water

Observations:

Questions:

1. Can you control conditions to produce equilibrium in this experiment?

2. Does this situation represent a single, simple equilibrium or is it complex?

3. When you loosen the cap and then tighten it on the closed bottle, what happens? Does this restore or disturb equilibrium?

4. Use the particle theory of matter to describe what happens to the equilibrium.

Conclusions and suggestions for further investigations:

Reporter ____________________ Date ____________________

Team Members ____

Problem: What conditions other than formation of a gas may prevent a reaction from reaching equilibrium?

Hypotheses:

Attack: Add a small amount of a sodium hydroxide solution to a copper nitrate solution. Note the formation of a solid substance. Add some ammonia solution.

Materials:

- solutions of copper nitrate, sodium hydroxide, and ammonia
- dropper for each solution
- test tube

Observations:

Questions:

1. Do the reactions represent situations where equilibrium can exist?

2. Without the presence of the ammonia the precipitate seems to remain the same in quantity. Why do you think it disappears partially or completely when ammonia is added?

3. Can you use the particle theory to describe the reactions you observed in this experiment?

Conclusions and suggestions for further investigations:

Reporter ______________________ Date ______________________ 12 1 page 248

Team Members ____

Problem: What additional information about particle size and motion can be obtained from a study of osmosis?

Hypotheses:

Attack: Use carrots as membranes; hollow them out so they can be used as containers as well.

Materials:

3 medium-sized carrots
granulated sugar
3 beakers or flasks
spoon
water
glass slides (as covers)
toothpicks

Observations:

Questions:

1. What do you think would happen if sugar solution were inside and outside the carrots but one solution was more concentrated than the other?

2. What conclusions can you draw about the size and motion of water molecules and sugar molecules?

3. What factors other than size and motion might govern the movement of substances through a membrane?

Conclusions and suggestions for further investigations:

Reporter ________________________ Date ____________________ 12 2 page 249

Team Members ____

Problem: Is the successive dilution of a solution helpful in determining particle size?

Hypotheses:

Attack: Put a single crystal of potassium permanganate into 50 ml of water. Split the amount in half. Save half and bring the other half up to the original volume. Split into halves again and bring half up to the original volume. Split into halves again and bring half up to the original volume. Follow this procedure looking for the existence of blobs or uniform color.

Materials:

- graduated cylinder
- several beakers
- crystal of potassium permanganate

Observations:

Questions:

1. What do you think you would see if you looked at the solution under a powerful microscope?

2. Relate your observations in this experiment to your observations in Experiments 6–4 and 7–3.

3. Do you now accept the particle theory and the particle motion theory as valid theories for matter?

Conclusions and suggestions for further investigations:

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